TRICHLOROETHYLENE

Identified as a toxic air contaminant under California's air toxic program (AB 1807) in 1990.

CAS Registry Number: 79-01-6 $Cl_2C=CHCl$

Molecular Formula: C_2HCl_3

Trichloroethylene is a chlorinated aliphatic hydrocarbon compound containing a double bond. It is a dense, nonflammable, volatile, colorless liquid which is only slightly soluble in water but miscible with organic solvents and other halogenated compounds. Most fixed and volatile oils are dissolved by trichloroethylene (Merck, 1989). It is lipophilic (ARB, 1990c). Trichloroethylene has an odor threshold of 28 parts per million (ppm) and smells similar to ether or chloroform (U.S. EPA, 1994a).

Physical Properties of Trichloroethylene

Synonyms: trichloroethene; ethinyl trichloride; Tri-Clene; Trilene; Trichloran; Trichloren; Westrosol; Gemalgene; Chlorylen; acetylene trichloride; 1,2,2-trichloroethylene

Molecular Weight:	130.40
Boiling Point:	86.7 ^oC
Melting Point:	-73 ^oC
Flash Point:	89.6 ^oC
Vapor Pressure:	100 mm Hg at 32 ^oC
Vapor Density:	4.53
Density:	1.4649 at 20/4 ^oC
Log Octanol/Water Partition Coefficient:	2.42
Conversion Factor:	1 ppb = 5.33$\mu g/m^3$

(HSDB, 1995; Merck, 1989; Sax, 1989; U.S. EPA, 1994a)

SOURCES AND EMISSIONS

A. Sources

Trichloroethylene is used in California in a variety of operations and products, including degreasing operations, polyvinyl chloride production, adhesive formulations, and paints and coatings. Trichloroethylene is also used in miscellaneous chemical synthesis and solvent applications, and as a refrigerant and heat exchange liquid. The major use of trichloroethylene in California, and nationwide is a degreasing solvent. It is not produced in California. Other sources that emit trichloroethylene include publicly owned treatment works; groundwater aeration

and air strippers; sanitary sewers; surface impoundments; and municipal landfills. Trichloroethylene is also present in trace concentrations in waste oil (ARB, 1990c). According to the World Health Organization in its review of trichloroethylene, the compound is widely distributed in surface water, rain water, and well water (WHO, 1985).

The California Department of Health Services (CDHS) measured a number of toxic compounds including trichloroethylene in large public water systems in California (DHS, 1986). Approximately 3,000 wells were sampled. Trichloroethylene was found in 188 wells with a median concentration of 3.2 micrograms per liter (μg/l). A maximum concentration of 538 μg/l was also reported. The CDHS noted that those wells supplying heavily urbanized areas generally had the higher concentrations of trichloroethylene. The CDHS developed an action level for trichloroethylene of 5 μg/l (ARB, 1990c).

The primary stationary sources that have reported emissions of trichloroethylene in California are manufacturers of pens, pencils, art and office supplies, manufacturers of motor vehicles and equipment, and manufacturers of miscellaneous fabricated metal products (ARB, 1997b).

B. Emissions

The total emissions of trichloroethylene from stationary sources in California are estimated to be 220,000 pounds per year, based on data reported under the Air Toxics “Hot Spots” Program (AB 2588) (ARB, 1997b). No control measures have been adopted for trichloroethylene under California's air toxic program.

C. Natural Occurrence

Trichloroethylene does not naturally occur in the environment (HSDB, 1995).

AMBIENT CONCENTRATIONS

Trichloroethylene is routinely monitored in California by the statewide Air Resources Board (ARB) air toxics network. When trichloroethylene was formally identified as a toxic air contaminant the ARB estimated a population-weighted annual concentration of 1.18 micrograms per cubic meter ($\mu g/m^3$) or 0.22 parts per billion (ppb). The network's mean concentration of trichloroethylene from January 1996 to December 1996 is estimated to be 0.176 $\mu g/m^3$, or 0.033 ppb (ARB, 1997c).

The United States Environmental Agency (U.S. EPA) has also compiled ambient air data from Lima, Ohio during 1990 to 1991. The data show a mean concentration of 0.71 $\mu g/m^3$ or 0.13 ppb. They also reported an overall mean concentration of trichloroethylene from 11 study areas during 1990 of 2.63 $\mu g/m^3$ or 0.49 ppb (U.S. EPA, 1993a).

INDOOR SOURCES AND CONCENTRATIONS

Trichloroethylene has limited use as a solvent in consumer products (U.S. EPA, 1987d) and indoor concentrations of this chemical have been found to be quite varied. The most recent California study was conducted in Woodland, California during the spring of 1990 (Sheldon et al., 1992). The indoor concentration of trichloroethylene of 125 homes ranged from 0.30 to 9.3 $\mu g/m^3$ or 0.06 to 1.74 ppb. The average indoor concentration was 0.65 $\mu g/m^3$ or 0.12 ppb.

The California Total Exposure Assessment Methodology (TEAM) studies were conducted during 1984 and 1987. Los Angeles and Contra Costa County were included during 1984, while Los Angeles was the only area for the 1987 study. Investigators collected volatile organic chemicals (VOC)s using personal air, outdoor, and fixed-site indoor samplers. Direct comparisons of trichloroethylene concentrations indoors and outdoors were matched. Mean indoor concentrations of trichloroethylene ranged from 0.63 to 3.97 $\mu g/m^3$ or 0.12 to 0.74 ppb. Median indoor concentrations of trichloroethylene are 2 to 5 times greater than ambient concentrations although indoor concentrations appear to be very dependent upon the use of consumer products containing trichloroethylene (Pellizzari et al., 1987b; 1989).

Concentrations of VOCs in 10 public-access buildings were monitored for three days. Volatile organic chemicals were measured at three new buildings before and after occupancy. Mean three-day trichloroethylene concentrations after occupancy ranged from 7.94 to 37.68 $\mu g/m^3$ or 1.49 to 7.07 ppb which the authors indicated could have been attributed to use of commercial cleaning products (Wallace et al., 1987).

ATMOSPHERIC PERSISTENCE

The primary removal mechanism of airborne trichloroethylene is its reaction with hydroxyl (OH) radicals in the troposphere. The calculated half-life and lifetime for trichloroethylene due to gas-phase reaction with the OH radical are estimated to be 4 days and 6 days, respectively. The reaction forms formyl chloride and phosgene and chlorine atoms (leading to hydrochloric acid formation in the atmosphere), together with other, unidentified, products (Atkinson, 1995).

AB 2588 RISK ASSESSMENT INFORMATION

The Office of Environmental Health Hazard Assessment reviews risk assessments submitted under the Air Toxics "Hot Spots" Program (AB 2588). Of the risk assessments reviewed as of April 1996, trichloroethylene was the major contributor to the overall cancer risk in 3 of the approximately 550 risk assessments reporting a total cancer risk equal to or greater than 1 in 1 million and contributed to the total cancer risk in 55 of the risk assessments. Trichloroethylene also contributed to the total cancer risk in 16 of the approximately 130 risk assessments reporting a total cancer risk equal to or greater than 10 in 1 million (OEHHA, 1996a).

For non-cancer health effects, trichloroethylene contributed to the total hazard index in 5 of the approximately 89 risk assessments reporting a total chronic hazard index greater than 1

(OEHHA, 1996b).

HEALTH EFFECTS

Probable routes of human exposure to trichloroethylene are inhalation and ingestion (U.S. EPA, 1994a).

Non-Cancer: Trichloroethylene is a central nervous system depressant and has been used as an anesthetic. It is mildly irritating to the eyes and respiratory tract. Occupational exposure to trichloroethylene has resulted in nausea, headache, loss of appetite, weakness, dizziness, ataxia, and tremors. Acute exposures to high concentrations has caused irreversible cardiac arrhythmias, nerve and liver damage and death. Chronic exposure to trichloroethylene has also been shown to cause respiratory irritation, renal toxicity, and immune system depression. Alcohol consumption in humans increases the toxicity of trichloroethylene and causes "degreaser's flush", red blotches on the skin (ARB, 1990c).

A chronic non-cancer Reference Exposure Level (REL) of 6.4×10^2 $\mu g/m^3$ is listed in the California Air Pollution Control Officers Association (CAPCOA) Revised 1992 Risk Assessment Guidelines. The toxicological endpoints considered for chronic toxicity are the central and peripheral nervous system, gastrointestinal system and liver (CAPCOA, 1993). The U.S. EPA currently is reviewing the Reference Concentration (RfC) and the oral Reference Dose (RfD) for trichloroethylene (U.S. EPA, 1994a).

There is inadequate information to determine whether trichloroethylene causes reproductive toxicity in humans. One study reported increased miscarriages in nurses exposed to trichloroethylene as well as other anesthetics. An association was found between elevated levels of contaminants, including TCE, in drinking water and congenital heart disease in children. Other studies have not reported adverse reproductive effects in humans exposed to trichloroethylene in drinking water. In animal studies, an increase in abnormal sperm morphology in mice exposed by inhalation was reported (U.S. EPA, 1994a). Exposure of rats and mice to trichloroethylene by inhalation causes a significant delay in fetal maturation and an increase in embryotoxicity (ATSDR, 1993h).

Cancer: The U.S. EPA considers the epidemiologic data on trichloroethylene carcinogenicity in humans to be inconclusive. Increases in testicular cancer have been reported in inhalation studies in animals (U.S. EPA, 1994a). Carcinogenic responses to trichloroethylene inhalation studies in animals are increased incidences of hepatocellular carcinoma and adenoma in male mice; lung adenocarcinomas and malignant lymphomas in female mice; malignant liver tumors in B6C3F1 mice; and renal tumors in rats (ARB, 1990c).

The U.S. EPA has classified trichloroethylene in Group B2/C: Probable human carcinogen (U.S. EPA, 1994a). The International Agency for Research on Cancer classified trichloroethylene in Group 2A: Probable human carcinogen, based on sufficient evidence in

animals and limited evidence in humans (IARC, 1995).

The State of California under AB 1807 identified trichloroethylene both as a carcinogen and as a Toxic Air Contaminant (ARB, 1990c). Trichloroethylene is also listed as a carcinogen under Proposition 65 (CCR, 1996). The inhalation potency factor that has been used as a basis for regulatory action in California is 2.0×10^{-6} (microgram per cubic meter)$^{-1}$ (OEHHA, 1994). In other words, the potential excess cancer risk for a person exposed over a lifetime to 1 $\mu g/m^3$ of trichloroethylene is estimated to be no greater than 2 in 1 million. The oral potency factor that has been used as a basis for regulatory action in California is 1.5×10^{-2} (milligram per kilogram per day)$^{-1}$ (OEHHA, 1994).